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Effects of Ozone and Water Stress on Net
Photosynthetic Rate of Field Grown Soybean Leaves

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Effects of Ozone and Water Stress on Net Photosynthetic Rate of Field Grown Soybean Leaves

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It is well documented that ozone (O_3) and soil water stress reduce the growth and yield of many agricultural crops. More detailed physiological measurements are needed, especially in controlled-field experiments, to better understand how these environmental stresses interact to affect the plant's physiology and growth. Therefore, a nondestructive technique was employed to measure, on a weekly and diurnal basis, the effects of O_3 and water stress on the net photosynthesis, stomatal resistance, and water status of leaves of field-grown soybeans. Open-top field chambers were used to expose soybean (*Glycine max.* (L.) Merr. cv Young) to three levels of O_3 at two levels of soil water at Raleigh, NC, as part of the 1986 NCLAN study. For the photosynthesis studies, the target O_3 levels were charcoal filtered air (CF), $1.3 \times O_3$ concentration of nonfiltered air (1-3 NF), and $1.9 \times O_3$ concentration of nonfiltered air (1-9 NF) yielding seasonal 12-h day⁻¹ mean concentrations of 0.018, 0.059, and 0.085 ppm (36, 118, and 170 $\mu g m^{-3}$), respectively. Soil water levels were well watered (WW) and water stressed (WS); the WS treatment was put through periodic drought cycles, while the WW treatment was irrigated whenever soil water tension exceeded -0.03 MPa. Each treatment had two replicates. Net carbon exchange rate (CER) was measured with the LI-6000 Portable Photosynthesis System (LI-COR, Inc., Lincoln, NB) on the center leaflet of trifoliolates selected for uniform exposure to sunlight. All measurements were taken between 1000 and 1230 h EST, the window of time that usually corresponded to peak-midday water stress. Two types of photosynthetic measurements were recorded: (1) weekly CER measurements at node 6 (counted from the plant apex) over the entire growing season, and (2) CER measurements during several different diurnal cycles. At each sampling, the treatment was characterized further for leaf water potential using Wescor Spanner thermocouple psychrometers. Additional leaf tissue was sampled and stored in 80% ethanol for subsequent measurement of nonstructural carbohydrates. The average CER rates over the growing season at node 6, as a percent of the CF treatment, were 75.0% and 55.1% for WW 1-3 NF and 1-9 NF, and 90.5% and 61.1% for WS 1-3 NF and 1-9 NF, respectively. The mean seasonal node 6 photosynthetic rates were 23.72×10^{-4} and 16.25×10^{-4} $\mu moles CO_2 cm^{-2} s^{-1}$ for WW CF and WS CF treatments, respectively. Final seed yields, as a percent of the respective water-CF

treatment, were 85.1% and 66.7% for WW 1.3 NF and 1.9 NF, and 88.3% and 68.2% for WS 1.3 NF and 1.9 NF.

The diurnal sampling on 14 September 1986 (Fig. 1) corresponded to approximately late pod fill (R6). Leaf water potential samples were taken at 0500, 0800, 1100, 1400, and 1700 h EST. The CER sampling period lasted approximately 60 min and began at 0600, 0900, 1200, and 1500 h EST. Several additional CER measurements were taken in the WW CF and WS CF plots to better characterize the diurnal photosynthetic curve. This day was essentially cloudless and the photosynthetically active radiation (PAR) had a bell shaped distribution that peaked with an hourly average of 1820

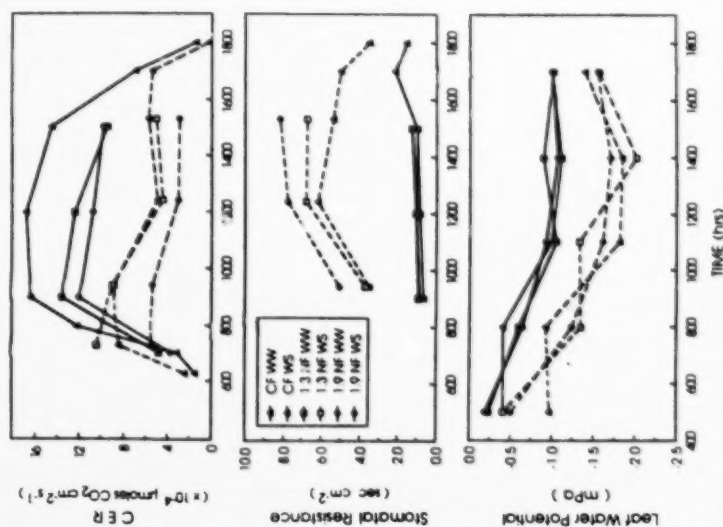


Fig. 1. Diurnal sampling on 14 September 1986 for net CER, stomatal resistance, and leaf water potential of field grown soybean leaves exposed to O₃ and water stress. Soil moisture treatments were well watered (WW) and water stressed (WS). Ozone levels were charcoal-filtered air (CF), 1.3 $\times$ O₃ concentration of nonfiltered air (1.3 NF), and 1.9 $\times$ O₃ concentration of nonfiltered air (1.9 NF).

microinstants $\text{s}^{-1} \text{m}^{-2}$ between 1200 and 1300 h EST. In each chamber, CER is the average of measurements on three center leaflets selected for uniform exposure to sunlight. One leaflet was punched for leaf water potential. The WW CF CER values (Fig. 1) are clearly the highest, and for most of the day, the 1.3 NF WW rate slightly exceeded the 1.9 NF WW. The WW CF and 1.3 NF photosynthetic rates are roughly the same, with the 1.9 NF WS much lower. As the water stress increased, the stomatal resistance increased across all WS CER. This increase in resistance corresponds to the decrease in the CER in the WS treatments. These results indicate that probably through stomatal closure water stress reduces the detrimental effect ozone has on leaf photosynthesis. The soil moisture treatment effects were evident in CER, stomatal resistance, and in leaf water potential measurements. The ozone treatment effects were present only in the WS stomatal resistance and in the WW and WS CER measurements. On this date, stomatal resistance increased with increasing ozone concentrations in the WS treatment.

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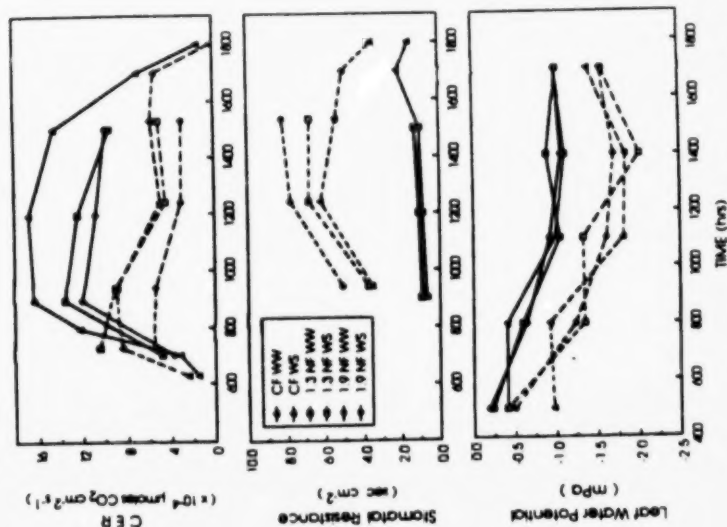


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